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ECONOMIC ADVANTAGES OF ENVIRONMENTAL RESEARCH

CONTRIBUTIONS OF THE SOUTHERN MARKETING AND NUTRITION RESEARCH DIVISION

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ECONOMIC ADVANTAGES OF ENVIRONMENTAL RESEARCH: CONTRIBUTIONS OF THE SOUTHERN MARKETING AND NUTRITION RESEARCH DIVISION

by

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INTRODUCTION

Much of the debate about pollution centers on the contention that reducing pollution costs too much to be practicable. However, Russell Train, Chairman of President Nixon's Environmental Quality Council, recently commented, "All that the pollution issue really is is an inefficient use of our resources" *(14)*[2]. If this premise is true—and we believe that it is—it follows that efficient use of our resources will not only reduce pollution but indeed be profitable.

The results of research to abate pollution obviously are more likely to be accepted by industry if they offer economic and environmental advantages. At the Southern Marketing and Nutrition Research Division (SMNRD), therefore, research on pollution is directed to this dual goal.

CONTRIBUTIONS OF PREVIOUS RESEARCH

Until recently, the reduction of pollution was not emphasized in research at SMNRD. Our primary objectives were to increase utilization of agricultural commodities and to provide the consumer with better products at lower cost. However, retrospective review shows that our previous research frequently achieved not only these primary objectives but also the important dividend of reduced pollution.

FROZEN CONCENTRATED ORANGE JUICE

An outstanding example of this dual accomplishment is frozen orange concentrate, which was developed at our Winter Haven laboratory in Florida in cooperation with the Florida Citrus Commission *(13)*. The new market that opened had an immediate and profound effect on the development and economy of the citrus industry. The importance of the effect can be assessed by a single statistic: today, the market for frozen orange concentrate is $1 million a day at the consumer level.

There is certainly, then, agreement about the economic advantages of this development. But what is its contribution toward reducing pollution?

Before frozen orange concentrate was developed, the principal method of marketing oranges was as fresh fruit. First, they had to be shipped all over the country. Then, somewhere along the line, all these oranges were either eaten as such or, much more frequently, squeezed for their juice. In either case, the residue was then discarded—45 to 50 per cent of the orange by weight.

In fact, if fresh oranges had been used last year instead of the frozen concentrate from Florida alone, approximately 4 billion pounds of garbage would have resulted from the residue.

But now 78 per cent of the Florida orange crop is used as concentrate. In relation to a comparable amount of fresh fruit, the use of orange concentrate makes these contributions to environmental quality:

(1) Instead of generating garbage throughout the country, the residue is kept at processing plants, where most of it is dried for use as feed.

(2) The fuel requirements for shipping are greatly reduced, conserving an important nonrenewable resource and reducing air pollution.

(3) The packaging materials to be discarded weigh only a fraction as much as the residue from the fresh fruit and present a far less serious disposal problem.

Thus, the development of citrus concentrate has made a major contribution to environmental quality and to the efficient use of our natural resources.

BYPRODUCTS FROM PROCESSING SWEET POTATO STARCH

Another contribution from our early research concerned utilization of byproducts from the commercial production of sweet potato starch. The starch itself was an excellent sizing agent for paper and textiles, but large quantities of wet pulp and fruit water remained after the extraction. The pulp was pressed, dried, and sold as feed, but disposal of the fruit water presented a troublesome problem.

Through research at SMNRD, processes were developed for recovering two useful products from the fruit water: protein and a medium for the growth of Torula yeast *(5)*. Removal of these constituents purified the fruit water sufficiently so that it could be discharged into natural waterways. Since the protein product and the yeast each contained about 50 per cent protein and the yeast was also a good source of vitamin B_1, they could be added to feed to enhance its nutritive value. A commercial yeast manufacturer is currently producing Torula feed yeast from sugarcane molasses by applying some of the basic propagation technology developed in this research.

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[1] One of the laboratories of the Southern Marketing and Nutrition Research Division, Agricultural Research Service, U.S. Department of Agriculture.

[2] Italicized numbers in parentheses refer to Literature Cited at the end of the report.

METHYL ESTERS FROM SOAPSTOCK

Another byproduct that created disposal problems was the soapstock produced during the refining of cottonseed oil. In the late 1950's, this soapstock had lost its major markets in soaps and fatty acids, and often actually cost money to get rid of.

Scientists at SMNRD developed a process for producing mixed methyl esters directly from acidulated soapstock, methanol, and a special catalyst *(6)*. The process was also applicable to soapstocks from soybean and corn oil.

From 1958 to 1967, 6 to 8 million pounds of the methyl esters from cottonseed oil were produced annually. Used as a high-energy additive in poultry and livestock feeds, they had nutritional and handling advantages over other types of byproduct fats.

CONTRIBUTIONS OF PRESENT RESEARCH

Although reduction of pollution was an important indirect result of previous research at SMNRD, our research program is also directly responsive to current needs and problems. Thus, as the pollution problem became critical, new lines of research were initiated to help solve it. The primary objective of this research is to reduce pollution associated with the processing of agricultural commodities, but another major goal is to create better and more profitable products or processing methods.

CITRUS

Peel Oil and Aroma Solutions

Few research developments provide triple benefits: recovering valuable new products from waste, abating the pollution problems that would result from their disposal, and providing materials needed to improve the properties of existing products. But scientists at our Winter Haven laboratory have developed a technique that promises to do all three. This development is particularly important because liquid waste from the manufacture of cold-pressed peel oil is among the worst pollutants from citrus processing.

An evaporation method *(18)* was developed for recovering volatile water-soluble aroma solutions and distilled oil from this waste material, which is usually about 1 per cent peel oil and 2 per cent other organic waste materials. By decreasing the organic content of the desludger effluent by 25 to 35 per cent, commercial application of this new recovery process will reduce disposal problems and potential stream pollution. Many processors in Florida have shown keen interest in the process, and at least two companies are already evaluating it.

The recovered aroma solutions and oil greatly enhance the flavor of frozen, canned, instant, and other citrus products, imparting to them the flavor of fresh fruit. Essence from orange juice itself is a premium product—$6 to $10 a gallon, 100-fold—but the amount of this essence needed to improve the taste of instant juice is greater than that available from an equivalent amount of fresh juice. However, a method has been developed for concentrating the recovered aroma solution so that the material obtained is capable of flavoring 2,000 to 4,000 volumes of juice.

Comminuted Citrus Products

Another contribution from recent research is the development of comminuted whole citrus products by researchers at our laboratory in Weslaco, Texas *(4)*. In the process for making these comminuted products, only the harder parts of the fruit, including the whole seeds, scaly parts of the peel, and most of the rag, are separated and rejected. Since the remaining 85 to 90 per cent of the whole fruit is converted into puree, obviously the problem of waste disposal is greatly diminished.

The puree can be diluted for citrus drinks (Figure 1) that have acceptable flavor, color, and other characteristics; when heat-processed and canned, they store successfully for a year. The puree can also be used in syrups, baked goods, and other food items.

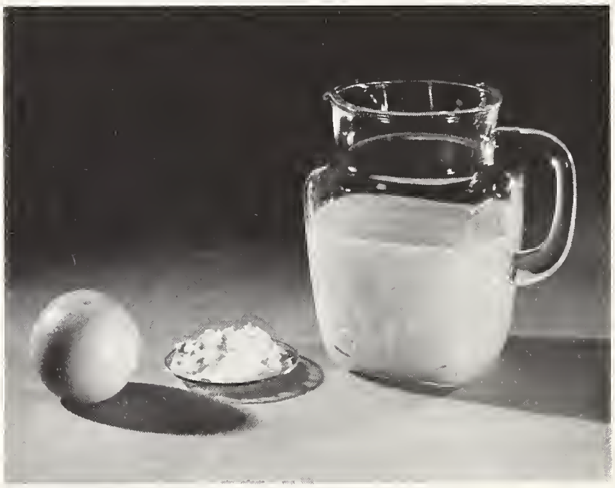

Figure 1. — *The orange drink in the pitcher was produced from 1 orange converted to puree and then properly diluted. In the center are the only parts of the fruit discarded.*

The resulting products should be competitive with those flavored by synthetic bases. Other advantages are that their food value is enhanced because a high proportion of nutrients is in the peel and pulp, processing costs are reduced, and more of the fruit is used for food instead of being diverted into less profitable feed markets.

Control of Emissions from Citrus Feed Mills

In addition to generating the liquid effluent already discussed, conventional processing of citrus also yields solid wastes, which are dried for feed, and press liquor, which is converted to citrus molasses.

Converting citrus wastes to dried feed and molasses now not only provides necessary disposal of the material but also brings a gross return of $27 million annually in Florida alone. But air pollution from particulate matter in the stack gases discharged from citrus feed mills has become a major problem, and the amount permissible is now restricted to 40 pounds per hour by Florida law.

Scientists at Fiske-Gay Associates, Inc., of Orlando, Florida, are now conducting research under contract to USDA to help solve this problem. By demonstrating different ways to adequately regulate emissions, this study *(16)* will permit plants of all sizes to achieve control at a cost they can absorb or, in some cases, at a profit—a major contribution to reducing pollution from this source.

To develop methods of control, the scientists conducted tests at three citrus feed mills of different design. The two plants that had both a feed drier to recirculate air and a waste heat evaporator were well below the tolerance for air pollution. The third plant, which had only an air scrubber on exhaust gases, was at first over the tolerance but has been remodeled and is now within permissible limits. In addition to decreasing pollution, use of the suggested methods has the additional advantage of greatly improving fuel efficiency.

OTHER FRUITS AND VEGETABLES

Cryogenic Peeling of Tomatoes

Commercial processes for peeling tomatoes cause losses from waste ranging from 10 to 50 per cent and thus contribute to pollution from cannery waste water. Most of the varieties of tomatoes grown in the South present even greater problems, because they are softer and yield processed products whose texture and consistency are less desirable than those of the same varieties grown in more temperate regions.

Our Weslaco laboratory has devised a process *(2)* for peeling tomatoes by spraying or immersing them in liquid nitrogen, liquid air, or Freon [3] just long enough to freeze the skin but not the flesh. When the tomatoes thaw, the skin slips off readily if it is broken or cut. In comparison with commercial methods, the new freeze-peeling process cuts losses in half and thus reduces pollution, reduces labor costs, and yields a product with better color and greater firmness. The peeled tomatoes are also more responsive to calcium treatments to make them even firmer, particularly for use in products such as salad packs. In cold storage, freeze-peeled tomatoes show superior firmness, resistance to drip, and prolonged keeping quality in comparison with heat-peeled tomatoes.

Many canners throughout the country have expressed interest in the new peeling process. In addition, two companies that make refrigerants have offered assistance in further development and presentation to industry.

Pure Culture Fermentation

Pure culture fermentation *(7)* has been called the first breakthrough in the basic process for pickling cucumbers and other vegetables in more than 4,000 years of pickle history. Developed by our Food Fermentation Laboratory at Raleigh in cooperation with the North Carolina and Michigan Agricultural Experiment Stations and the National Pickle Packers Association (now Pickle Packers International, Inc.), it should present fewer disposal problems with salt and acid wastes than the conventional brining process. In addition, it will enable processors to improve quality, tailor flavor characteristics, offer new products, and reduce costs.

In the age-old method of pickling in vats, fermentation depends on lactic acid bacteria that enter the brine solution by chance. In the controlled process, however, the undesirable and interfering naturally occurring microorganisms are inactivated. The cucumbers are washed, heat treated, packed in containers, seasoned with spices, and then covered with a pasteurized acidified salt brine. Each container is inoculated (Figure 2) with the bacteria culture desired and then sealed. In contrast to the lengthy conventional method, the new pickling process is complete within a week, although flavor continues to develop for a longer period. The process has also been applied to tomatoes, peppers, carrots, and other vegetables and to Manzanillo olives *(8)*.

Figure 2. – *Inoculation of vegetables for pure culture fermentation.*

Industrial representatives have scheduled a short course to teach other pickle packers how to apply the new procedure commercially. Eight companies, including several giants of the food processing industry, have put up test packs of pure culture pickles in institutional-sized containers or plan to do so this season.

Dry Caustic Peeling of Sweet Potatoes

The most acute waste disposal problem in commercial processing of sweet potatoes results from the caustic peeling operation. In this operation, the caustic, the peel, and other materials are introduced into large volumes of water and end up as pollutants in processing plant effluents.

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[3] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

However, a new peeling process, called "dry" caustic peeling because it removes most of the peel tissue mechanically without the use of water, will greatly reduce this effluent. The process, which was originally developed by the Western Marketing and Nutrition Research Division (WMNRD) for white potatoes *(9)*, has now been modified for sweet potatoes through a cooperative effort between WMNRD and SMNRD.[4]

Briefly, dry caustic peeling of sweet potatoes consists of pre-heating the sweet potatoes in water, immersing them in a hot lye solution, draining them, heating them by intense infrared radiation to concentrate and activate the absorbed caustic, removing most of the peel with rotating rubber-tipped rollers, and brush washing with a small amount of water to remove any remaining peel residue and to impart a polished surface to the peeled sweet potatoes. The peel residue may be neutralized to reduce the pH so that it can be utilized as animal feed.

Celery Oil from Wastes

Researchers at our Winter Haven laboratory have devised several processes for obtaining flavorful celery oil from parts of the fresh celery plant now discarded as trimming waste *(19)*. The preferred process—continuous atmospheric distillation—yields an oil whose flavor and aroma closely resemble that of fresh celery. In this process, celery leaves, tops, and outer ribs are heated to drive off 10 to 20 per cent of their moisture; these vapors are trapped; and the volatile oil is separated from them. Although a relatively small amount of oil is removed, the biochemical oxygen demand of the residue to be discarded is significantly reduced.

A ton of waste yields as much as 250 ml of oil, theoretically enough to flavor the dried product from a ton of celery. In addition to improving the flavor of processed celery products, the oil should find widespread use as a seasoning for other foods. It has a better flavor and is more potent than oil extracted from celery seed or made synthetically.

COTTON

Although this report has focused primarily on fruits and vegetables so far, a major part of the research at SMNRD is on cotton. Since textile processing can produce a considerable amount of stream and air pollution, our research on cotton has offered an opportunity to help solve these problems.

Purification of textile wastes is much more complex than most other industrial pollution problems because of the wide variation in the type of wastes. Historically, most of the mills in the southeastern region have been located near rivers or streams, where large quantities of water are available. However, this proximity also means that large quantities of effluent are discharged into streams as an economical means of disposal.

The wastes from desizing, scouring, and mercerizing constitute about 70 per cent of this objectionable effluent. Two recent developments at SMNRD should help alleviate pollution from these stages of textile finishing.

Permanent Sizing

The first is the development of permanent sizing *(12)* to eliminate the usual desizing step that causes so much stream pollution. The new permanent sizing consists of polymers such as polyurethanes or polyacrylates applied to yarn before it is woven. In addition to its usefulness in reducing pollution, permanent sizing has another advantage: a lower concentration of agents can be used to produce durable-press fabrics with improved strength and abrasion resistance. A commercial slasher (Figure 3) can be used without modification to apply the permanent sizing. At present, the process is being evaluated by several textile mills.

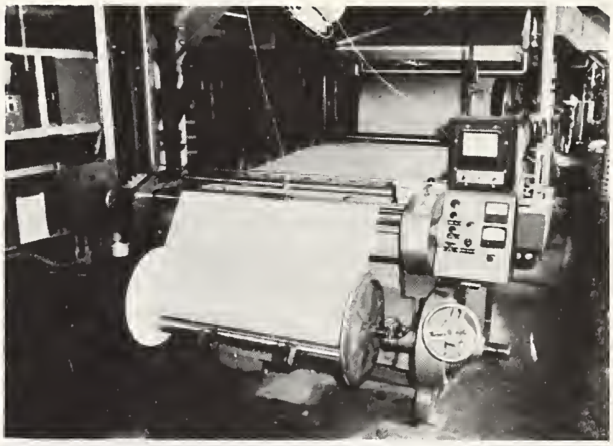

Figure 3. — *Commercial slasher used for application of permanent sizing.*

Ammonia Mercerization

In the second development, an improved liquid-ammonia mercerization process (3) has been devised to replace conventional mercerization using sodium hydroxide. The ammonia can be reclaimed, and the organic material removed from the fabric can also be collected and utilized. Again, there are other advantages: not only is ammonia mercerization faster than conventional mercerization, but the properties of subsequently treated durable-press fabric are also considerably improved. Through the use of an 11-roll chainless mercerizer (Figure 4), which was designed and developed at SMNRD, it has proved practicable to mercerize fabrics under tension on a continuous basis.

Processes for ammonia mercerization have also been announced abroad *(17)*. In the United Kingdom, liquid ammonia is beginning to be used commercially to mercerize cotton sewing thread. And in Norway, a

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[4] Spadaro, J.J., Ziegler, G.M., Jr., Gallo, A.S., and Huxsoll, C.C. Unpublished information, 1970.

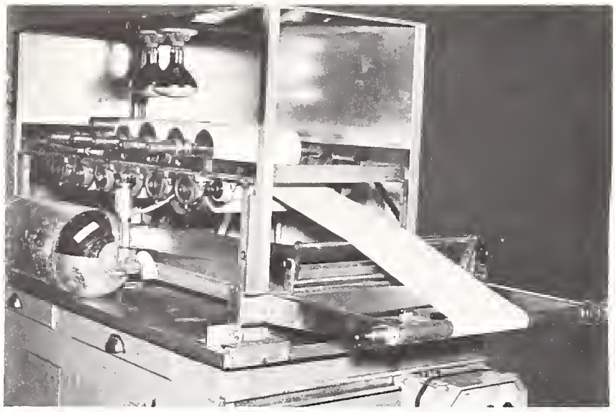

Figure 4. – *Eleven-roll chainless mercerizer used for continuous mercerization with liquid ammonia.*

process aimed at mercerizing fabrics is expected to be commercialized soon.

Nonaqueous Finishing

Eliminating or reducing effluent from individual steps in the finishing of cotton, as just described, is one approach. Another approach is the use of nonaqueous agents throughout the total system of cotton finishing. Processes for the preparatory steps are already available either commercially or on a laboratory scale. Now SMNRD scientists are studying methods for applying durable-press finishes to cotton fabric from organic solvents *(15)*. The pilot-plant equipment is shown in Figure 5. The durable-press finishing process now used commercially is a pad-dry-cure process and therefore does not itself involve the discharge of effluent. However, development of a nonaqueous system for durable-press finishing could provide the last link needed to permit industrial use of a completely nonaqueous finishing system.

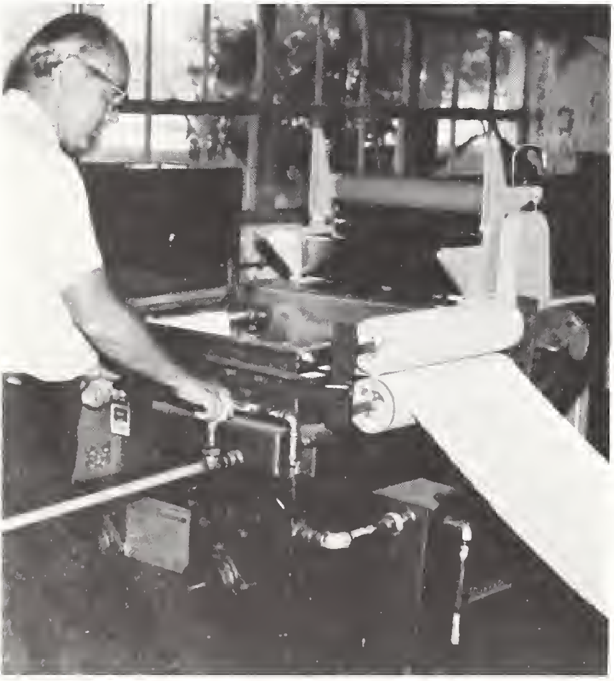

Figure 5. – *Pilot-plant equipment used for applying durable-press finishes from nonaqueous solvents.*

POTENTIAL CONTRIBUTIONS OF FUTURE RESEARCH

Consideration of the pollution problem as a whole will of course influence our selection of specific lines of research in the future. In general, the emphasis in protecting and improving the environment will be on expanded use of renewable resources and conservation of nonrenewable resources.

An obvious way in which the use of renewable resources can be expanded is the development of processing methods to reduce wastes. The ideal, of course, is a completely closed system in which only the products desired are generated and the materials needed in processing can be reused.

In practice, however, the ideal is rarely achieved. To be realistic, we must recognize that much more frequently wastes are generated together with the product desired. Our major problem, then, is optimum utilization of these wastes. Through the development of new and improved processing technology, what we now call "wastes" will be transformed into profitable byproducts. Even garbage could be reclaimed: possibilities for the future include recovery of fats and oils for industrial and feed uses, reclamation of paper as such or for its cellulosic components, and separation and reuse of glass and metals.

Better processing methods will also lead to conservation of nonrenewable resources, such as petroleum, gas, and coal. For example, increased use of dehydration would make an important contribution. If the technology for dehydration can be developed sufficiently so that virtually all foods and beverages are shipped and stored water-free, many of the advantages already described for frozen citrus concentrate will be achieved on a much larger scale. As stated then, one of the major advantages was that the reduced weight greatly decreased the amount of fuel required for shipping.

Based on these general considerations, here are a few specific examples of the types of research planned for the future:

One approach is to reuse materials in the same processing system or to use them for another purpose. For example, in the fermentation of fruits and vegetables, the brines could be recovered and reused. Or sodium chloride in the brining solution could be replaced with other inorganic salts, particularly those that contain nitrogen or potassium. The spent brine could then be used as a liquid fertilizer.[5]

A second approach is to remove potential pollutants from agricultural commodities or byproducts before they are used. Naval stores products offer an interesting possibility. In the extraction of oleoresin from pinewood chips, an appreciable quantity of oxidized rosin is sometimes left on the chips, causing a very black smoke when they are burned for fuel. However, preliminary investigations suggest that one additional step in the extraction procedure will not only greatly reduce pollutants in the smoke but also yield an additional 5 to 8 per cent of dark oxidized rosin.[6]

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[5] Etchells, J.L. Unpublished information, 1970.

A third approach is to use agricultural commodities to remove pollutants from other materials. For example, previous research *(10, 11, 1)* suggests that aminized cotton cellulose may be useful for this purpose. Since this type of cotton is positively charged, it should attract and immobilize negatively charged bacteria and possibly viruses from contaminated water. It should also remove mercury. And it can take up soil released from clothes during laundering.

Other future research on pollution will be directed toward solving problems connected with typical agricultural residues in the South: canning wastes such as peels, pits, seeds, pulp, and liquid extracts from fruits and vegetables; peanut shells; rice and cottonseed hulls; bagasse; sweet sorghum wastes; and spent liquors from the production of protein isolates.

Future research will continue to show that guarding the environment can be compatible with improving a product or reducing its cost.

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